IDENTIFYING FACTORS THAT AFFECT POLITICAL FEASIBILITY OF CLIMATE- AND ENERGY-RELATED POLICIES

by
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Abstract

Climate change is an urgent problem. Due to anthropogenic greenhouse gas emissions, the average planet is warming at an alarming rate, causing large-scale changes to ecosystems humans depend on. Additionally, since what we emit today get locked into the Earth's atmosphere for hundreds of years, time is of the essence. The problem's size requires policy intervention at scale, and there is an opportunity cost of delayed policy action. Forgoing an incremental policy in order to pursue sweeping, but delayed, policy may hinder the ability to stay below the 1.5 degrees C threshold identified by the IPCC. Climate change policy in the U.S. has been particularly challenging to pass. Because of the critical time aspect of this issue, it is important to understand why this is and what factors impact political feasibility, or the ability of a bill or measure to be passed, in hopes of informing policy advocates of what legislation or actions to target going forward. This research looks at data models of past ballot initiatives at the State level and Federal climate legislation to quantify relationships between measurable and political feasibility factors. The model identified a significant negative relationship between percent voted yes and campaign finance spent in opposition and a significant positive relationship between percent voted yes and percent Hispanic at the State ballot box. However, in general, results were not conclusive on many of the factors being tested, signaling that more research and data is needed on what causes voters to vote in a certain way on climate- and energy-related measures. At the Federal level, campaign donations and partisan identity were strong, significant predictors. This re-emphasizes the need to depolarize the issue by reaching across the aisle to find common ground and a potential need for campaign finance reform, such as a ban on donations above 4% of total fundraising from a given sector (in this case, the energy and natural resources sector).

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Executive Summary

The EPC program has helped me develop a broader understanding of the intersection of science, technology, and policy on the issue of climate change. From a scientific perspective, having a strong scientific foundation on earth and ocean dynamics, captures the magnitude, gravity, and complexity of the problem. This program has helped me identify the causes and effects of a changing climate, backed with strong scientific evidence. It is from this foundation that technological and policy solutions need to be approached and supported. From a technological perspective, addressing the scale of the problem will require research, development, and deployment of new and emerging technologies. Economies will need to be transformed by these technologies in order to decarbonize and avoid the worst effects of climate change. Transformational change however will not happen on its own – it needs strong policy support. At this point in time, a decarbonized economy is more expensive and would result in a many "losers", willing to spend a lot of money to avoid acknowledgment of climate change and misinform the public in order to protect their business. The policy pillar is integral in increasing the adoption of new technologies, achieving economies of scale, and correcting market inefficiencies born from the negative externality (social cost) of carbon. It is from these foundational pillars that I embarked on this Capstone Project. This research acknowledges the importance of policy in driving our ability to stay below the scientifically backed 1.5 degree C threshold. By attempting to quantify and measure the political feasibility of a climate or energy-related policy, I search for insight into how the U.S. could change course to improve the likelihood that meaningful legislation gets passed. Science tells us that timing is critical and we need new technological solutions; policy should be crafted to support these realities, but also in a way that can garner widespread public and congressional support so that we can start relieving pressure on our limited carbon budget.

Introduction

Climate change, the increase in global average temperature due to anthropogenic greenhouse gas emissions, can be described as an urgent humanitarian crisis. Even small changes in temperature can have devastating effects on natural ecosystems and weather patterns, affecting the systems that humans depend on. Moreover, the faster the climate changes, the harder it will be to adapt to those changes. Since the pre-industrial period, anthropogenic greenhouse gas emissions have already contributed to about 1 degree C increase in global temperature. At our current rate, we could be passing the critical 1.5 degrees C threshold established by the IPCC likely between 2030 and 2050 (Buis 2019). Additionally, infrastructure investments in energy and transportation systems lock-in outcomes for significant periods of time, since these kinds of projects last for decades, which can lead to lag times in the effects of new policy (Gilligan 2014). It is under this context that time is of the essence. Gilligan (2014) highlights the importance of political feasibility in climate change instrument choice because the timing of policy implementation to tackle climate change is so important, where delaying adoption of a sub-optimal policy may be at the expense of attempting to pass the optimal policy to no avail.

In order to address the challenge of climate change, humans need to quickly move towards a more sustainable and carbon-free economy in a short period of time. More specifically, to limit the world to warming of only 1.5 degrees C, the IPPC report estimates that CO2 emissions would need to be cut in half from 2010 levels by 2030, with the target of net zero by 2050 (IPCC 2018). 2030 is less than 10 years out, and the US has yet to enact meaningful climate and energy-related policy at scale to address the scale of the problem. There is an opportunity cost of unrealized emissions reduction from policies that may not meet the scale of the problem but could have made progress in the interim. Why has progress on this issue been so difficult?

There are many potential answers to that question. This work aims to explore factors impacting the political feasibility of climate- and energy-related policy to provide more insight into why some policies pass and others fail. The likelihood of a policy getting passed can be termed as "political feasibility". Research shows political feasibility to be context dependent and contingent on probabilistic constraints – such as resource shortages, opposing interest groups, or technology availability – and the assessment of political feasibility may therefore depend on which constraints fall within the realm of the policy maker's influence or control (Jewell and Cherp 2019; Gilabert and Lawford-Smith 2012). Context dependence also implies that a policy that may have failed in the past can still be politically feasible in the future. On climate change, decreasing costs of decarbonization and increasing the capacity of relevant actors within the space can lead to greater political feasibility of supportive climate policies (Jewell and Cherp 2019). To understand what other attributes may contribute to political feasibility of a climate or energy related policy, I will study two research questions:

RS1: *What factors are most likely to impact the probability that a climate change or energy related policy is passed at the ballot box?*

RS2: *What factors are most likely to impact the likelihood that a member of Congress votes yes on climate change or energy related policy?*

I hypothesize that right-leaning political party affiliation - of a voting population or a Congress member - more money spent on lobbying efforts against, and the longer ago it was proposed all significantly decrease the probability that an energy or climate-related measure or bill is passed. As demonstrated from research, climate change has become a politically polarized issue, where those on the right side of the political spectrum are less likely to prioritize the issue or even think that it is happening (Leiserowitz et al., 2019); therefore, I expect to also see this association in the voting records. Additionally, research shows that climate change has become more visible in the media over the years, as shown in Figure 1 below (Boykoff et al. 2020).

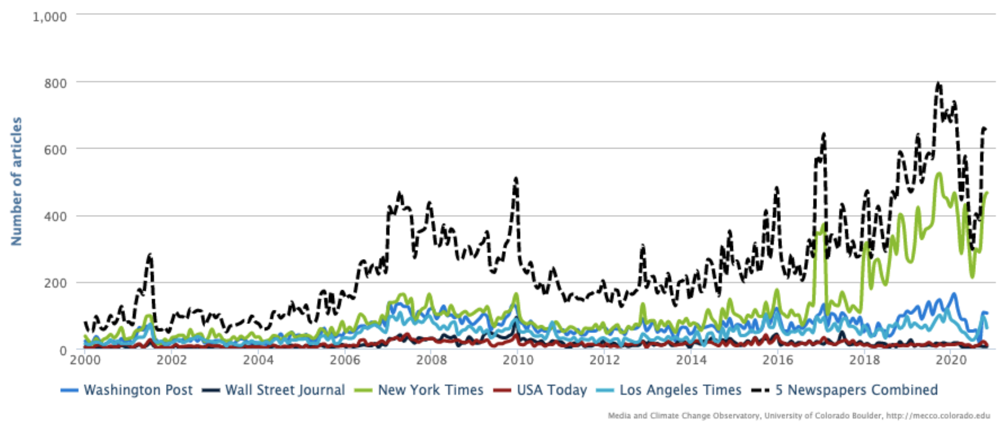


Figure 1: 2000 – 2020 U.S. Newspaper Coverage of Climate Change or Global Warming

Brulle, Carmichael, and Jenkins (2012) show that media coverage has a significant impact on public concern over climate change, and so in correlation with the rise in media coverage, it has risen as a priority in public sentiment since 2008, particularly among democrats (PRC 2020). However, it is also important to consider how prioritization of climate change has changed during economic downturns. In the US, recent evidence shows that just before COVID hit, environmental concerns rivaled economic concerns as a top political priority for the first time in nearly two decades of data collection (PRC 2020). However, the same data also demonstrates the issue remains highly polarized between political factions. Interestingly, since COVID, multiple studies have found that the current economic downturn has not impacted levels of concern regarding climate change, demonstrating levels at or near historic records (Tyson and Kennedy 2020; Leiserowitz et al. 2020). This differs from the Great Recession, where research showed a strong and robust relationship between environmental protection prioritization decreasing as unemployment levels increased (Kenny 2019). To control for and test this theory, the modeling done at the state level in this study will include a measure on the public perception of climate change, as estimated by the percent of people in the state that believe climate change is happening and is caused by humans (Yale Climate Opinion Maps 2020), and the annual unemployment rate. After controlling for these measures, I expect to see a relationship between the year of the bill and its probability of passing, with later years having higher probability.

I also hypothesize that these relationships will be stronger in Federal legislature than at the ballot box because, at the ballot box, I am assuming these measures are generally one of many, the voter is anonymous, and the average voter is not very well informed, whereas a vote on the Congress floor has higher visibility, and the person voting has a reputation they have to uphold to please constituents and/or donors. Furthermore, it is precisely because the average voter is not very well informed that I believe the voter is more susceptible to certain persuasion campaigns' prominence. Lastly, I am interested in seeing in RS1 whether the model identifies the kinds of policies that have a higher likelihood of passing (based on categorical variables) and if there is a significant relationship between the perceived climate impact or costs of the policy the probability of it passing.

Current knowledge in the field has found mixed evidence regarding how campaign finance impacts policy outcomes (Powell 2012). Researchers have found that campaign finance's influence may depend on the policy issue – specifically how visible and understood the issue is by the public – and how indebted legislators are to their donors (Craig and Madland 2014; Powell 2012). However, numerous studies demonstrate that businesses with the most to gain or lose are also the most likely to engage in political activity. These business interest groups are often successful in shaping policy outcomes (Craig and Madland 2014). This is of particular concern for the issue of climate change, as there are powerful business interests who stand to lose a lot if significant climate change policy is enacted. Cragg and Kahn (2009) have also shown partisanship to be a key factor that influences legislative decision-making processes when it comes to the issue of climate change. Counties with higher per-capita carbon emissions, which are also more likely to be poorer, are more likely to be represented by Republicans. Therefore, it may be theorized that Republicans are more likely to vote against climate legislation because of the financial burden or economic harm it would bring to the area; however, the evidence shows that even while holding district per-capita carbon and income constant, Republicans are more likely to vote against climate legislation (Cragg and Kahn, 2009). Additionally, it is important to note that this study assumes substituting away from carbon is more costly. However, as technology advances, the cost of carbon-free technology has and will continue to decrease – in many cases, building new renewable generation is less expensive than operating existing coal plants (IRENA 2020). In order to reach economies of scale where these cost reductions can occur, higher levels of deployment are needed; this can often be supported through policy initiatives.

Though review of history may not be a leading indicator of what is to come, this research seeks to expose important relationships and trends that can help inform what factors influence the probability of a policy passing and under what circumstances on the issue of climate change in the near-term, and to consider the political opportunity cost of delayed action so that progress can be made.

Methods

Data

For RS1, the data collection process encompassed deciding which ballot measures to include, and then for each ballot measure, collecting the following information: state, year, topical tags, percent of vote, financial impact, ballots cast, and campaign finance information. Then for each state, in order to establish a relationship between the voting population and the ballot results, data was collected on: voting age population, partisanship of state legislature, latest state budget, average age, percent male, percent white, percent Hispanic, public perception on climate change, and unemployment rate. The source of each variable is demonstrated in Table 1 below.

Table 1: Data Sources.

Variable	Source
Measure	National Conference of State Legislatures (NCSL) Statewide Ballot Measures Database
State	National Conference of State Legislatures (NCSL) Statewide Ballot Measures Database
Year	National Conference of State Legislatures (NCSL) Statewide Ballot Measures Database
Topical Tags	National Conference of State Legislatures (NCSL) Statewide Ballot Measures Database
Financial Impact	Ballotpedia
Percent Vote Yes	Ballotpedia
Voter Turnout	Ballotpedia
Campaign Finance	Ballotpedia
Partisanship of State Legislature	Ballotpedia
Voting Age Population	U.S. Census Bureau, Population Division
Average Age	U.S. Census Bureau, Population Division
Percent Male	U.S. Census Bureau, Population Division
Percent White	U.S. Census Bureau, Population Division
Percent Hispanic	U.S. Census Bureau, Population Division
Public Perception: Percent that think climate change is happening	2020 Yale Climate Opinion Maps
Unemployment rate	Bureau of Labor Statistics, U.S. Department of Labor
State Budget	Wikipedia: List of US State Budgets

The following steps were taken to curate a data set of relevant state ballot measures related to energy and climate. First, I retrieved a list of all potentially relevant ballot measures via the National Conference of State Legislatures (NCSL) database. The search filtered from years 2008 to 2019 and the topics of energy, electricity, transportation, and agriculture, but included all states, measures, and election types. For measures that were only tagged as transportation, it was excluded unless the measure's sole focus was mass transit or a fuel tax. For measures that were only tagged as agriculture, the measure was excluded unless it specified sustainable farming or conservation practices. Second, I used research from the Energy Innovation Policy Simulator on the effectiveness of different types of energy and climate-related policies to determine a climate impact score between 0 to 4 based on a policy category, as demonstrated in the table below. Each ballot measure was mapped to a category here and assigned this score for climate impact. The climate impact variable is designed to convert context dependent information of the measure to a numeric scale. If a ballot measure worked negatively against climate impact in one of these categories, I took the inverse of the percent yes, and flipped the campaign finance money for and against, such that all ballots were framed as a vote yes is a vote associated with positive climate impact.

Table 2: Policy categories and associated climate impact score assignments

Category	Climate Impact Score
Protection of lands/parks, environmental conservation, revitalization , restoration	1
Protect wildlife/biodiversity/habitats	1
Protect water quality and clean drinking water	1
Energy efficiency	2
Water conservation/efficiency	1
Renewable Energy Standard/Mandate	4
Motor vehicle fuel tax, increased vehicle license/registration fees	0
Incentives for alternative energy (fuels for transportation, DERs)	2
Improve air quality	2
Personal vehicle alternative - public transit, high speed rail investments, bike/pedestrian lanes	2
Increase taxes on oil and gas industry	3
Encouraging competition in energy markets (e.g. deregulation)	4
Cap on emissions (e.g. cap and trade)	3
Waste reduction (incentive to recycle or ban on certain materials)	1
Carbon tax	3
Barriers for oil and gas development, or fossil fuel extraction (e.g. mining)	3
Climate adaptation, e.g. flood infrastructure	1

A similar conversion took place related to interpreting the financial analysis and impact information of the measure and producing a cost scale, shown below.

Table 3: Rules for Cost Scale Assignment

Cost Scale	Rule	
-1	Increases taxes on corporations	
0	Ambiguous	
1	Low	< 1% state budget
2	Medium	<= 5% state budget
3	High	> 5% state budget

This data collection process resulted in 69 state ballots to be included in a linear regression model. For 11 of the 69 cases, small adjustments were made to the generic category to climate impact score mapping using justification based on the details of the measure, as demonstrated in Table 4 below.

Table 4: Context-based adjustments to climate impact score and justification

Measure	State	Year	Climate Impact Score	Impact Category	Design Adj	Adj Reason
Proposition 7	CA	2008	4	Clean Energy Standard	-5	So poorly written that it could hurt the cause of renewable energy in the state
Proposition 21	CA	2010	0	Vehicle/gas tax	1	Funds are dedicated to parks
Advisory Vote 2	WA	2012	3	Tax on fossil fuels	-1	Delaying expiration - not a new tax
Advisory Vote 10	WA	2015	3	Tax on fossil fuels	-1	Retain - not a new tax
Proposition 65	CA	2016	1	Waste reduction	-1	Doesn't affect use of plastic just redirects money
Proposition 68	CA	2018	1	Conservation	1	Combination of parks, wildlife, and water
Proposition 6	CA	2018	2	Invest in personal vehicle alternative	-1	Mixed impact on highways versus public transit
Amendment 9	FL	2018	3	Barriers to fossil fuel development	-1	Oddly paired with a vaping component.
Proposition C	MO	2008	4	Clean Energy Standard	-1	Weak goal/standard.
Constitutional Amendment	AL	2010	2	Energy Efficiency	-2	Energy efficiency but for a fossil fuel technology.
Ballot Measure 1	AK	2014	3	Barriers to fossil fuel development	-1	Only applies to a specific location of interest.

For RS2, this research looked at three major federal climate legislation proposals: The Climate Stewardship Act of 2003, The Climate Stewardship and Innovation Act of 2005, and The American Clean Energy and Security Act of 2009. Upon research, these bills are recognized as the most prominent climate legislation that saw a vote on the Congress floor in the last 20 years. The first two bills were voted on in the Senate, and the third was voted on in the House. Voting records for each of these bills were pulled from either govtrack.us or congress.gov/roll-call-votes. These records provided the result of how each individual congress member voted on particular legislature, including his or her party and state affiliation. For the campaign finance cycle that included the year of the vote, OpenSecrets.org provided information on total campaign finance raised by "Campaign Committee & Leadership PAC Combined" for the individual in the industries of mining, electric utilities, oil and gas, and chemical manufacturing, as well as the total from the energy and natural resources sector for each Congress member. Supplemental data for this model included emissions per capita by state, as provided by U.S. Energy Information Administration, and the composition of the state legislature, as provided by Ballotpedia. In the RS2 data collection process, I randomly sampled 30 Senate members from the first two voting records and 50 House members from the third voting record by assigning a number to each voter and then using a random sample generator to select the study participants.

Analysis

For RS1, I modeled an ordinary least squares (OLS) linear regression on the percentage of voters that voted yes on the measure. Although a linear regression model is able predict values that aren't possible, i.e. values below 0 or above 1, and the relationship is actually sigmoidal (between 0 and 1), this isn't a large concern because the majority of the data fell within 0.3 and 0.7, which is the linear part of the sigmoidal curve. I ran three versions of the model to test different theories of the environment:

1) Ballot measure attributes only – ballot measure attributes drive the ability to predict the outcome.

$$
\begin{aligned}
Y_{Percent\ Yes} = \ & b_0 + b_1 X_{climate\ impact} + b_2 X_{campaign\ finance\ for} \\
& + b_3 X_{campaign\ finance\ against} + b_4 X_{is\ environmental\ protection} + b_5 X_{is\ tax} \\
& + b_6 X_{is\ bond} + b_7 X_{is\ transport} + b_8 X_{is\ energy} + b_9 X_{is\ agriculture}
\end{aligned}
$$

2) State attributes only – attributes of the voting population drive the ability to predict the outcome.

$$
\begin{aligned}
Y_{Percent\ Yes} = \ & b_0 + b_1 X_{state\ legis\ rep} + b_2 X_{voter\ turnout} + b_3 X_{avg\ age} + b_4 X_{pct\ male} \\
& + b_5 X_{pct\ white} + b_6 X_{pct\ hispanic} + b_7 X_{public\ perception} \\
& + b_8 X_{unemployment\ rate}
\end{aligned}
$$

3) Combined ballot and state attributes – the combination of both ballot measure attributes and voting population characteristics drives the ability to accurately predict a measure outcome.

$$
\begin{aligned}
Y_{Percent\ Yes} = \ & b_0 + b_1 X_{state\ legis\ rep} + b_2 X_{voter\ turnout} + b_3 X_{avg\ age} + b_4 X_{pct\ male} \\
& + b_5 X_{pct\ white} + b_6 X_{pct\ hispanic} + b_7 X_{public\ perception} \\
& + b_8 X_{unemployment\ rate} + b_9 X_{climate\ impact} + b_{10} X_{campaign\ finance\ for} \\
& + b_{11} X_{campaign\ finance\ against} + b_{12} X_{is\ environmental\ protection} \\
& + b_{13} X_{is\ tax} + b_{14} X_{is\ bond} + b_{15} X_{is\ transport} + b_{16} X_{is\ energy}
\end{aligned}
$$

In order to select the appropriate features, I started with all relevant variables included in the model and then dropped variables one by one without significance or that do not improve the fitness (explanatory power) of the model, as measured by R-squared. R-squared varies between 0 and 1, with higher values indicating stronger model fit. I also used the root mean squared error (RMSE), an indicator of the standard deviation in Y's variability not explained in the model, to compare model fit across models. A lower RMSE value indicates better fit.

For RS2, I tested a logistic regression on whether or not a member of Congress voted for or against the proposed policy. Similarly, I started with all variables of interest included in the model and then filtered down to only include the statistically significant variables, or that were important to address my hypothesis.

$$Y = log_b \frac{p}{1-p}$$

$$= b_0 + b_1 X_{is\ rep} + b_2 X_{yr} + b_3 X_{proportion\ energy} + b_4 X_{is\ male}$$

$$+ b_5 X_{state\ legis\ pct\ rep} + b_6 X_{emissions\ per\ capita} + b_7 X_{tenure}$$

The factors that are most likely to impact the probability of a policy passing or the likelihood of a Congress member voting yes are determined based on the size and significance of variables modeled. A variable is considered significant if it has a p-value less than 0.05, meaning there would be less than a 5% we would see this result if the null hypothesis – that the coefficient is equal to 0 – were true.

Exploratory

RS1 State Ballot Measures

California is the most represented state in this sample with 13 ballot measures, followed by the state of Washington with 9 ballot measures, compared to the sample median of 2 ballot measures per state. The chart below demonstrates the proportion of climate- and energy-related ballot measures that passed (Vote Yes) by state, though it does not provide any insight into the type of ballot measure that was considered.

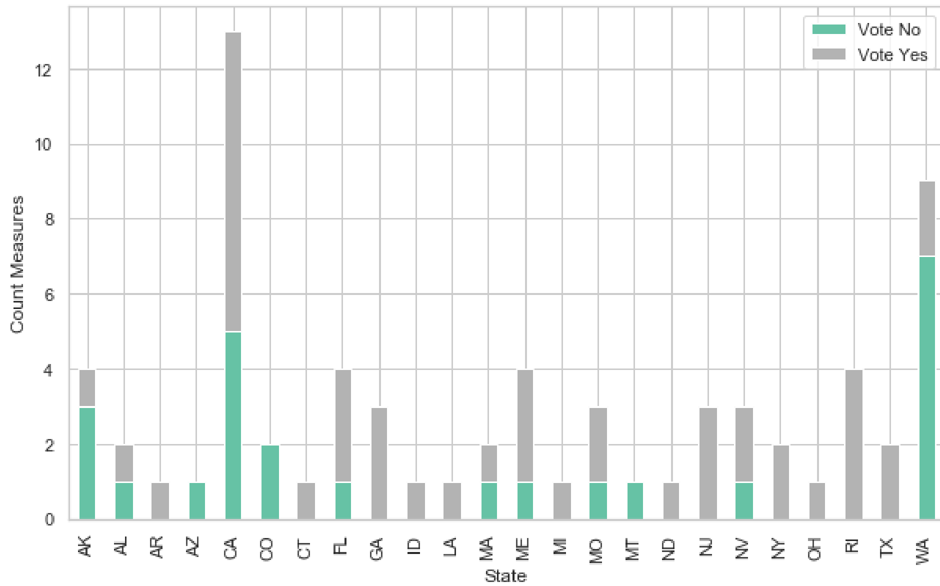


Figure 2: Measures Included by State

The most common categorical assignment was “Conservation”. “Conservation”, “Invest in personal vehicle alternatives”, and “Climate Adaptation” had the highest proportion measures passed at 95%, 100%, and 100% respectively. “Tax on fossil fuels” and “Vehicle/gas tax” had the lowest proportion measures passed at only 20% and 25% respectively.

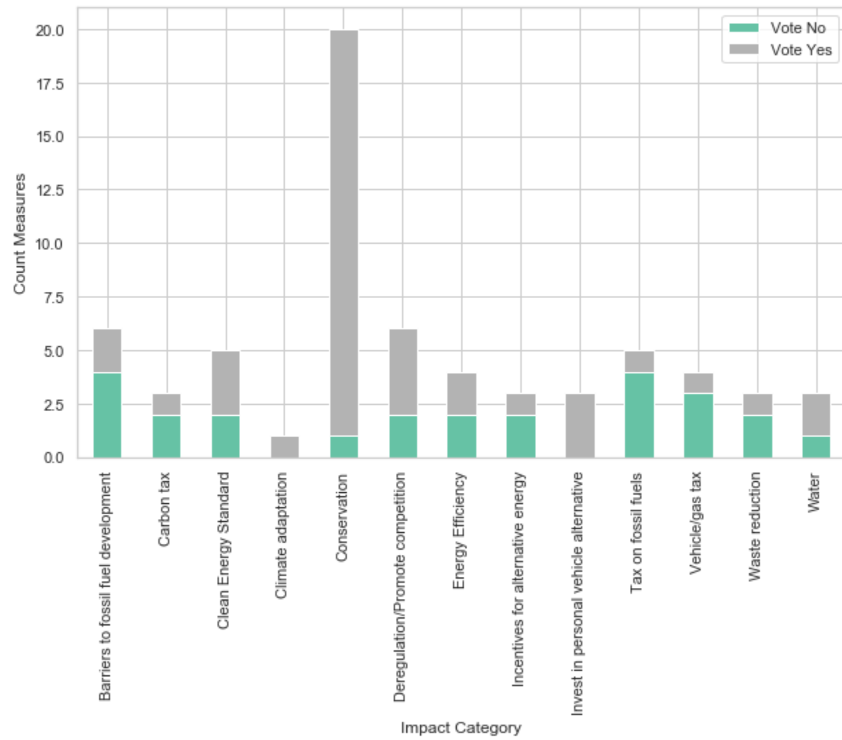
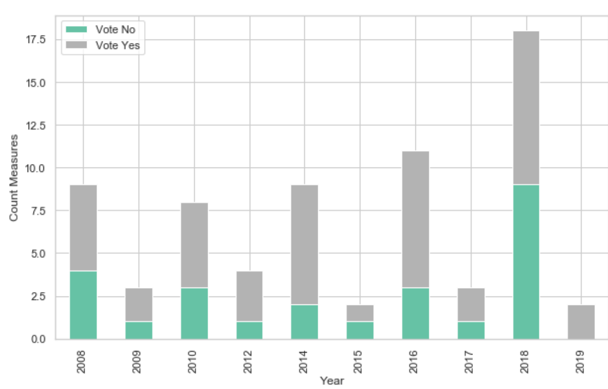
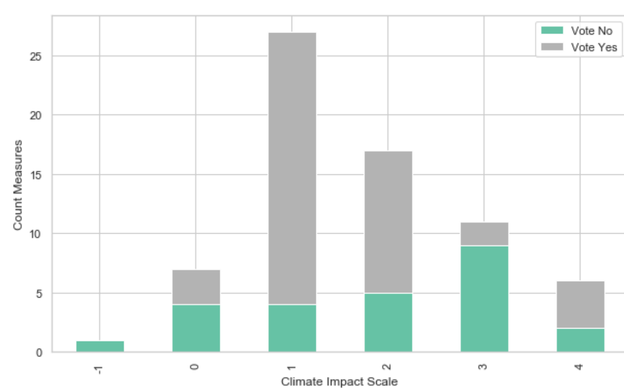


Figure 3: Measures Included by Policy-Assigned Impact Category

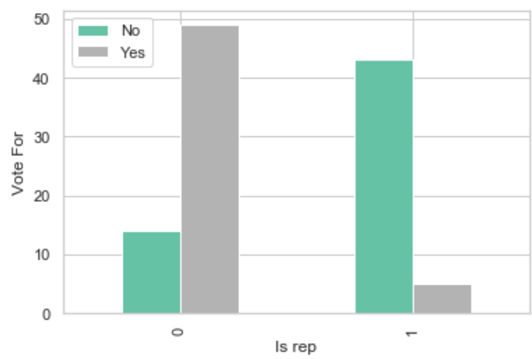
If we look at the percent of climate- and energy-related ballot measures that passed by Year and by Climate Impact Scale, there are no clear trends in increasing likelihood over time or deceasing likelihood with higher impact.

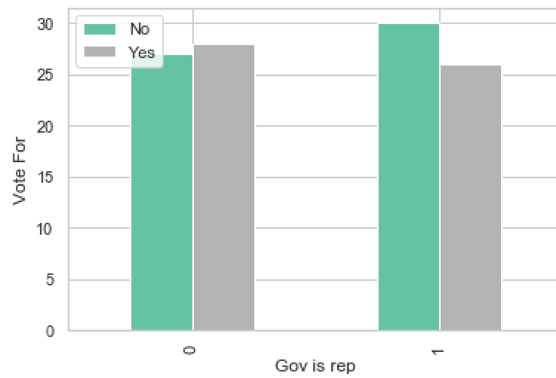


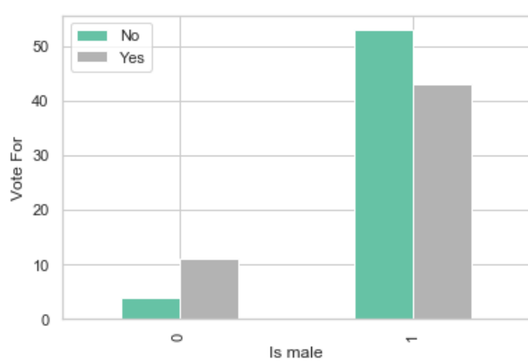


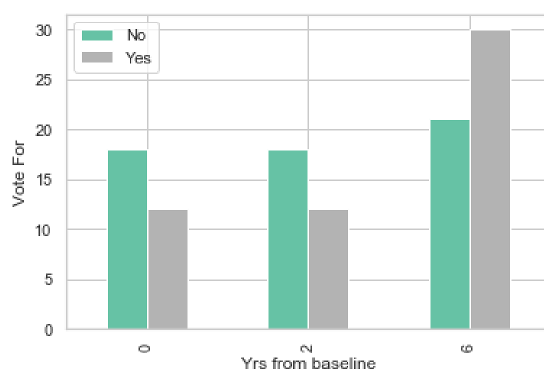
RS2 Federal Legislation

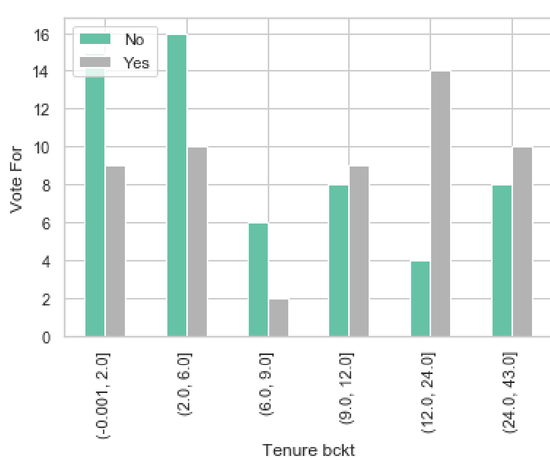
The series of bar charts below demonstrate clear differences in voting records by each categorical variable. These charts suggest that a Republican is more likely to vote no; a Congress member in a State with a Republican governor is more likely to vote no; a Male is more likely to vote no; a vote in later years is more likely to be yes; and a member with longer tenure (over 9 years) is more likely to vote yes.











Results

RS1: *What factors are most likely to impact the probability that a climate change or energy related policy is passed at the ballot box?*

The table below summarizes a comparison of the three models run for RS1. Following are the detailed analysis results by model.

Table 5: RS1 Summary Table

Regression Model	R-squared	RMSE	Significant Variables (coeff)	Linear Fit
Model (1) Ballot-attributes only	0.394	0.111	Money Against (-5.32e-9) Is Transportation (-0.15) Is Energy / Electric (-0.07)	Poor
Model (2) State-attributes only	0.269	0.121	Percent Male (-4.58) Public Perception (-1.33)	Poor
Model (3) Combined	0.47	0.103	Money Against (-5.48e-9) Is Transportation (-0.15) Is Energy / Electric (-0.07) Percent Hispanic (0.27)	Fair

Model (1) Ballot attributes only

Table 6: OLS Regression - Ballot-attributes

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.6994	0.050	14.044	0.000	0.600	0.799
climate_impact_score_adj	0.0069	0.015	0.461	0.646	-0.023	0.037
climate_yes_money_for	-3.564e-10	1.77e-09	-0.202	0.841	-3.9e-09	3.18e-09
climate_yes_money_against	-5.318e-09	1.5e-09	-3.546	0.001	-8.32e-09	-2.32e-09
cost_scale	-0.0300	0.023	-1.281	0.205	-0.077	0.017
is_environmental_protection	-0.0631	0.038	-1.664	0.102	-0.139	0.013
is_bond_measure	0.0325	0.055	0.590	0.557	-0.078	0.143
is_tax_revenue	-0.0168	0.040	-0.422	0.674	-0.096	0.063
is_transportation	-0.1531	0.048	-3.194	0.002	-0.249	-0.057
is_energy_electric	-0.0737	0.037	-2.013	0.049	-0.147	-0.000
is_agriculture	-0.0661	0.056	-1.188	0.240	-0.178	0.045

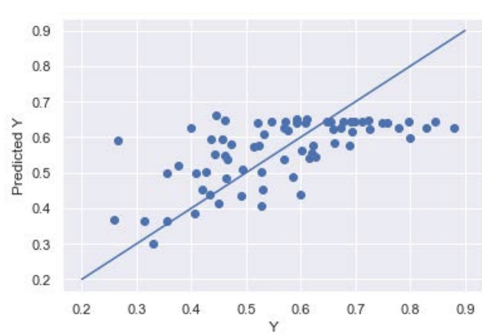


Figure 4: Predicted Probability from Regression Results Against Actuals – Ballot-attributes

This regression model tested a theory that only what is in the ballot measure itself affects what the proportion voted Yes would be. This model's R-squared is 0.394, signifying that 39.4% of the variation in the proportion voted Yes on a measure is explained by X here. The root mean squared error (RMSE) is 0.111, which is interpreted as this model resulting in a 11.1% standard deviation of the unexplained variance in the proportion voted Yes. Lastly, when plotting the actual Y values against the predicted Y values, as shown in Figure 4, the model results are not particularly linear, which indicates this may not be the right model fit, or that the model is missing key variables to control for differences in the variation of Y.

Following the criteria that a coefficient is a significant predictor if the p-value is less than 0.05, the significant predictors in this model are campaign finance money spent against, whether the measure is transportation-related, and whether the measure is energy- and electric-utilities-related. Based on this model, if there is no campaign finance money spent for or against, no climate impact, ambiguous costs, and no topical indicators, the average proportion voted Yes on a measure is predicted to be 69.9%. Holding all else constant: a $1,000,000 increase in campaign finance spent against a measure decreases the predicted proportion voted Yes by 0.53%; a topical tag of transportation decreases the predicted proportion voted Yes by 15.3%; and a topical tag of energy and electric utilities decreases the predicted proportion voted Yes by 7.4%.

Model (2) State attributes only

Table 7: OLS Regression - State-attributes

	coef	std err	t	P>|t|	[0.025	0.975]
const	4.2475	1.660	2.559	0.013	0.926	7.569
state_legis_is_rep	0.0706	0.149	0.475	0.637	-0.227	0.368
voting_age_pop	-7.681e-10	3.5e-09	-0.219	0.827	-7.78e-09	6.24e-09
voter_turnout_pct	-0.1647	0.115	-1.433	0.157	-0.395	0.065
avg_age	-0.0051	0.019	-0.272	0.787	-0.043	0.033
pct_male	-4.5817	2.067	-2.216	0.031	-8.718	-0.445
pct_white	-0.2337	0.254	-0.921	0.361	-0.741	0.274
pct_hispanic	0.3134	0.302	1.038	0.304	-0.291	0.918
public_perception	-1.3352	0.662	-2.016	0.048	-2.660	-0.010
unemployment_rate	-0.8803	0.835	-1.054	0.296	-2.552	0.791

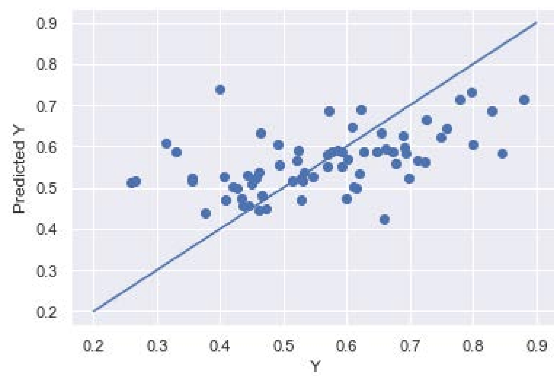


Figure 5: Predicted Probability from Regression Results Against Actuals - State-attributes

This regression model tested a theory that it is only the attributes of the voting population on the ballot measure that affects what the proportion voted Yes would be. R-squared of this model is 0.269, signifying that only 26.9% of the variation in the proportion voted Yes on a measure is explained by X here. The root mean squared error (RMSE) is 0.121, which is interpreted as this model resulting in a 12.1% standard deviation of the unexplained variance in the proportion voted Yes. The lower R-squared and higher RMSE here signify a worse fit than model (1). In this case, when plotting the actual Y values against the predicted Y values in Figure 5, the model results are more linear than model (1), but the high residual values still indicate this may not be the right model fit, or that the model is missing key variables to control for differences in the variation of Y.

Following the criteria that a coefficient is a significant predictor if the p-value is less than 0.05, the only significant predictors in the model are the percent male of the voting population and public perception. Based on this model, if each variable is assigned the mean value of that predictor, the average proportion voted Yes on a measure is predicted to be 56.2%. Holding all else constant, as the percent male increases by 1%, the predicted outcome decreases by 4.5%; as the percent of population that believes climate change is happening and is human-caused increases by 1%, the predicted outcome decreases by 1.3%.

Model (3) Combined

When I combined controlling for state level attributes with measuring the ballot measure's attributes, the model performed much better at predicting the outcome. Here, I started with all variables from models (1) and (2), and then removed one non-significant predictor at a time and addressed the impact on R-squared – if R-squared dropped by more than 0.01, I kept the variable in the model, otherwise, it was dropped. Additionally, I removed the variable public perception because it had a fairly high correlation (r=0.6) with two of the other predictors (percent Hispanic and state legislation percent Republican). This resulted in a high R-squared model (r=0.547) and low root mean squared error (RMSE=0.096). These two metrics signified a better fitting model than both the ballot-attributes theory and the state-attributes theory. However, the results indicated potential multicollinearity in the model. This interferes with our ability to interpret the coefficients of the model because it means one of the predictors can be explained by the other predictors, and so if one of the predictors moves, the others move too. Therefore, we are not able to isolate the effect of each variable on its own. In order to address this, I looked at Variable Inflation Factors (VIF), which measures for each variable, how well it is described by the other independent variables. A VIF exceeding 10 indicates high multicollinearity, and so I dropped variables with a VIF above 10 until I was left with only independent variables that have a VIF below 10. Beginning with these variables, I remodeled the regression.

Table 8: OLS Regression Results - Combined

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.6107	0.096	6.380	0.000	0.419	0.802
climate_impact_score_adj	0.0090	0.014	0.638	0.526	-0.019	0.037
climate_yes_money_against	-5.475e-09	1.35e-09	-4.064	0.000	-8.17e-09	-2.78e-09
cost_scale	-0.0382	0.021	-1.777	0.081	-0.081	0.005
is_environmental_protection	-0.0714	0.037	-1.928	0.059	-0.145	0.003
is_bond_measure	0.0981	0.053	1.857	0.068	-0.008	0.204
is_transportation	-0.1541	0.043	-3.576	0.001	-0.240	-0.068
is_energy_electric	-0.0704	0.035	-2.024	0.048	-0.140	-0.001
is_agriculture	-0.0604	0.053	-1.136	0.261	-0.167	0.046
state_legis_is_rep	0.1989	0.108	1.843	0.071	-0.017	0.415
pct_hispanic	0.2699	0.134	2.011	0.049	0.001	0.539
unemployment_rate	-0.9867	0.632	-1.561	0.124	-2.252	0.279

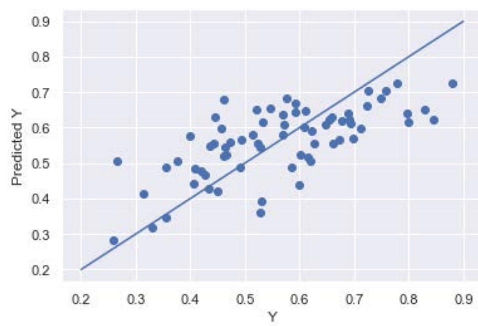


Figure 6: Predicted Probability from Regression Results Against Actuals - Combined

The model resulted in a R-squared of 0.47 and RMSE of 0.103, which reflects slightly worse explanatory power, but higher interpretability of significant variables. Notably, the percent male had a high VIF; even though this variable contributed significantly to the model's explanatory power, it impacted interpretability and was therefore excluded from this version of the model. In this version, when plotting the actual Y values against the predicted Y values, the model results are more linear than both model (1) and (2), with smaller residual values, which can be observed as the points are closer to the line in Figure 6; however, there appears to be a slight skew in that the model systematically appears to under predict the percent outcome for measures resulting in over 65% voted Yes.

Multiple predictors in this model pass the criterion for significance. Of note is that the climate impact scale, cost scale, percent of the legislature that is republican and the unemployment rate are all not significant predictors at the 0.05 significance level. Predictors that were significant in the model include campaign finance money spent against, topical tags of transportation and energy and electric utilities, and percent Hispanic. Holding all else constant, a $1,000,000 increase in campaign finance spent against a measure decreases the predicted proportion voted Yes by 0.55%. Additionally, a topical tag of transportation, energy and electric utilities, environmental protection, and agricultures decreases the predicted proportion voted Yes by 15.4%, 7.1%, 7.0%, and 6.0% respectively, signaling that a transportation measure is least likely to pass, followed by energy and electric utilities and environmental protection, and then agricultural, which is the topic most likely to pass; however, the agriculture tag is also not significant, likely due to the fact that there was not a large enough sample of agricultural measures within the sample to determine its effect. Lastly, holding all else constant, a 1% increase in the percent Hispanic of the population increases the predicted proportion voted Yes by 0.27%.

RS2: *What factors are most likely to impact the likelihood that a member of Congress votes yes on climate change or energy related policy?*

Table 9: Logistic Regression

	coef	std err	z	P>|z|	[0.025	0.975]
is_rep	-2.8073	0.693	-4.051	0.000	-4.165	-1.449
yrs_from_baseline	0.2867	0.103	2.795	0.005	0.086	0.488
proportion_energy	-68.7577	19.725	-3.486	0.000	-107.417	-30.098
is_male	1.2768	0.696	1.836	0.066	-0.087	2.640
tenure	0.0921	0.035	2.640	0.008	0.024	0.160

Table 10: Log Odds of Coefficients

	Log Odds
is_rep	6.036558e-02
yrs_from_baseline	1.331988e+00
proportion_energy	1.376986e-30
is_male	3.585325e+00
tenure	1.096452e+00

The variables for republican governor, percent state legislature that is republican, and state emissions per capita all do not improve model accuracy, precision, or recall and are not significant, and therefore are dropped from the model. The remaining independent variables result in a model with an accuracy, precision, and recall all around 90%. Figure 6 below demonstrates the Confusion Matrix (left) and Receiver Operating Characteristic (ROC) curve of the model (right), respectively. The Confusion Matrix demonstrates the number of predicted true positives (top left), true negatives (bottom right), false positives (bottom left), and false negatives (top right). The ROC curve plots the true positive rate (TPR) against the false positive rate (FPR) – here the curve is close to the top-left corner, which indicates good performance.

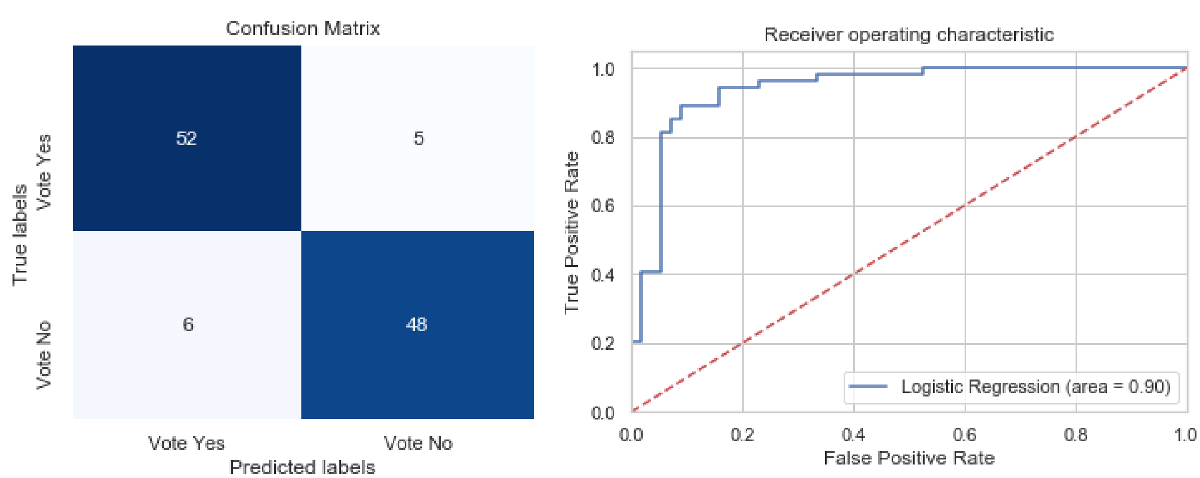
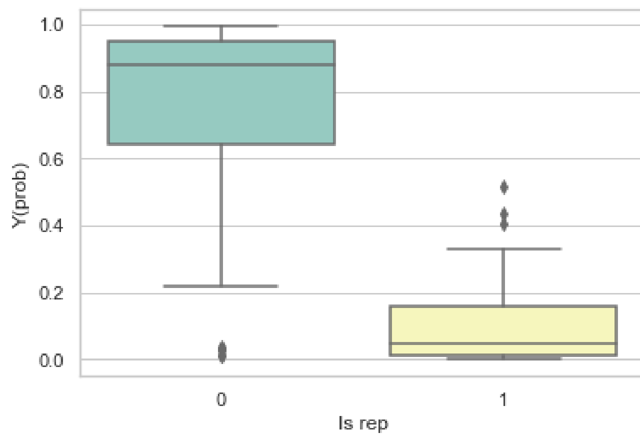
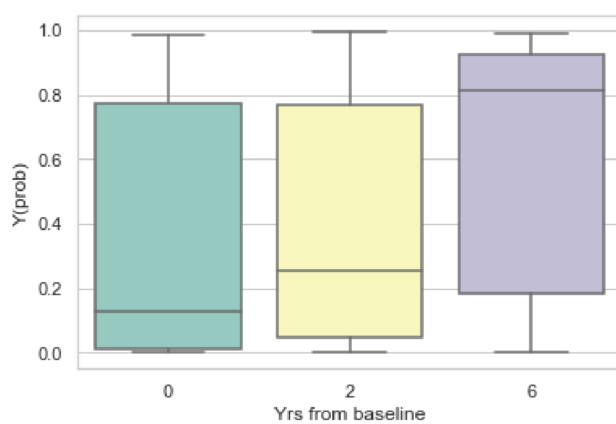


Figure 7: Indicators of Model Performance

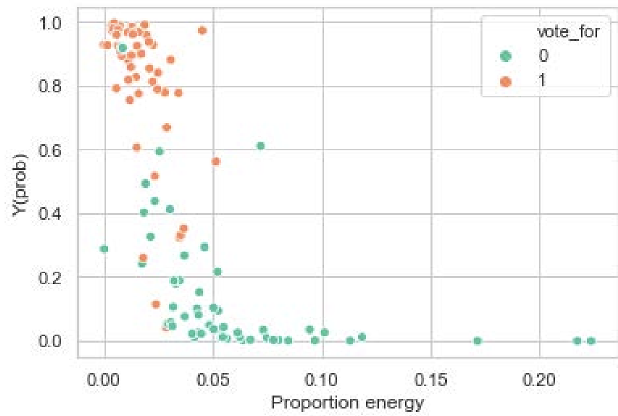
If we plug in the mean values of all variables into the model, it would result in a 33% probability that a Congress member votes Yes. Holding all else equal, the odds of voting Yes is 94% lower for Republican Congress members than Democrat or Independent counterparts. The box plot below demonstrates the clear divergence in the distribution of the predicted probability based on whether or not the study participant is a Republican.



The odds of voting Yes is 33% higher for each year out from 2003. The box plot below shows that the mean and distribution of the probability for voting Yes shifts higher as the years out increases.



The odds of voting Yes are more than 99.99% lower for every 1% increase in the proportion of funding that comes from the energy and natural resources sector. Based on the graph below, there appears to be an exponential decline in the probability of voting Yes as the proportion of campaign finance from the energy and natural resources sector increases.



Lastly, the odds of voting Yes are more than 259% higher for male Congress members; and the odds of voting Yes is 9.6% higher for each additional year of tenure the Congress member has.

Discussion

Through this research, I cannot identify whether these observed relationships are causal because there are likely confounding variables that are not measurable or that I am not able to hold constant, as you would in an experimental design with a control and treatment group. I address some of these confounding variables in the section below. However, I think modeling this data does provide some insight into the strength of relationships and predictability of an outcome as attributed to the variability in the explanatory variables measured here. Even without the ability to claim causation, these relationships matter because they expose the often-negative consequences of money in politics and how partisan ideology can trump content of a bill or measure. This highlights the importance of two key aspects that may help the political feasibility of energy- and climate-related policy: campaign finance reform and de-polarization of the issue by finding bi-partisan grounds.

RS1: *What factors are most likely to impact the probability that a climate change or energy related policy is passed at the ballot box?*

A general assumption I make in this research is that observable and measurable attributes affect whether or not a climate or energy policy is "successful", as measured by its probability of passing. However, most aspects of political feasibility may be related to what goes on behind closed doors and what the negotiations look like, which are more difficult to measure and not included in my research. For example, it is often said in policy that “the devil is in the details”. Though I have tried to capture qualitative attributes as quantitatively measured variables in my models, I have not been able to capture all the details that may impact how much impact a policy could have on energy and climate, and what other parties may be affected by the measure based on the details of measure. I believe this is part of the reason why the variable to measure climate impact scale was not a significant predictor. Even if the measure may have addressed aspects of energy and the environment that would impact climate, based on the level of detail I observed for each bill, which is likely more than the detail an average voter would have, it is very difficult to conclusively perceive what impact the policy would have. Therefore, the insignificance of the predictor simply indicates that there is no clear relationship between climate impact and probability of passing likely due to the fact that most citizens are not actively engaged and educated on the issue of climate change and the role policy can play. Similarly, as it was difficult to create a methodology to standardize the quantification of costs associated with a policy, I assume it would also be difficult for voters to assess the voter's financial impact and/or to the state budget. It is for this reason that I think the cost scale variable was also insignificant.

There was no clear and significant merit order of topical tags to indicate the types of policies that have a higher likelihood of passing, besides the finding that transportation-related measures had the lowest likelihood of passing. The transportation related measures were most often vehicle or gas taxes, which voters often misperceive as having a larger impact than they actually have and therefore are more likely to reject (Fisher and Wassmer 2014). This may be part of the reason why we observe this outcome. Surprisingly, there was not enough evidence to reject the null hypothesis that both right-leaning political party affiliation (in the state) and the year of the measure coefficients are 0. The lack of clarity in the relationship between Republican representation in the state and the probability of passing may be due to differences between the bills that get introduced in Republican versus Democratic states. Imagine, Bill A is introduced to a Republican state and and Bill B is introduced to a Democratic state and they both have the same probability of passing; however, because of nuances in each bill (not captured in the model), it is possible that if Bill B were instead introduced in a Republican state, it may have a very different outcome. Additionally, because the sample skews towards California and Washington propositions, it may be that there was not enough data on Republican-leaning states to tease out significance in the model.

A potential reason for why the year was not proven to be significant is because the distribution of states in which energy and climate-related ballot measures get proposed differ from year to year. Another theory may be that even though climate change has become a more pressing issue over the years, the misinformation campaign around the topic also increased substantially, largely funded by fossil fuel companies and the Koch brothers (Leonard 2019).

The percent Hispanic was the strongest predictor on the state attributes side in predicting likelihood of passing, specifically that a higher Hispanic population was correlated with a higher probability of passing. This is in line with past research that has shown that the Hispanic population is disproportionately affected by climate change or environmental issues and is more likely to say global warming is caused by humans (Krogstad 2015; Latino Decisions 2016). One potential action item is to increase the number of registered Hispanics and encourage more of their vote in order to help get climate legislation passed. However, one limitation to note is that the state attributes looked at the demographics of the voting age population, but not necessarily the demographics of the population who actually voted on the measure (due to lack of availability on that data). Additionally, California is an over-represented state in this sample and is a state with a higher Hispanic population than most other states.

The campaign finance money spent against was the most significant predictor on the ballot attributes side in predicting likelihood of passing. Interestingly, campaign finance money spent for was not proven to be significant or to increase the model's explanatory power. Replacing the two variables with one variable measuring the spread in campaign finance for and against was significant but decreased the explanatory power of the model (R-squared) by more than 7% as compared to just using the variable for money spent against. This demonstrates that campaign finance is a powerful tool when it comes to voter persuasion in state politics. On average, for the votes that passed, $1.8 million more was spent for the bill than against. For the votes that didn’t pass, $5.4 million more was spent against the bill than for. This is in line with past research and is also a grave concern because those who stand to lose from climate change policies have deep pockets.

Additionally, the inclusion of unemployment rate in the model provided weak evidence (p-value = 0.12) for the theory that climate- and energy-related measures get deprioritized (lower likelihood of passing) when the economy is suffering, as measured by a higher unemployment rate.

In all three models, it can be observed that the models are not very good at predicting Y values over 65%, though model 3 shows improvements from models 1 and 2. As mentioned in the Analysis section, the relationship we are modeling via a linear regression is actually sigmoidal, which is not a problem as long as the outcomes mainly fall between the linear portion of the sigmoidal curve (0.3 to 0.7). I believe the reason why points over 65% have higher residual values are because these points start to approach the non-linear part of the sigmoidal curve.

Lastly, it is important to acknowledge that states address climate policies in different ways. For example, this study focused only on ballot measures at the state level. So it tended to favor the states that are more likely to measure the people on energy and climate, such as California. In contrast, other states that are active in policy-making in this area but do not approach policy making through the ballot box, such as New York, are underrepresented. Additionally, it is worth pointing out that the over-representation of California and Washington in this sample – simply due to the fact that this research utilized the entire population of relevant ballot measures between 2008 and 2019 and these two states had the highest number of measures – means that these results may not be generalized broadly to all States in the US. Future research could use stratified sampling techniques by creating two sub-populations of ballot measures, one for red-leaning states and one for blue-leaning states, and then taking a random sample from each of those two populations to try to create a more representative sample. However, this method would likely result in a fairly small sample size from which it could also be difficult to draw conclusions.

RS2: *What factors are most likely to impact the likelihood that a member of Congress votes yes on climate change or energy-related policy?*

As hypothesized, party affiliation (-), campaign finance (-), and year of bill (+) were all significant predictors in modeling whether or not a Congress member would vote for or against climate legislation. Interestingly, party affiliation is not generalized to the partisanship of the state – as having a Republican governor or strong Republican state legislature were not significant – but only to the partisan identity of the voting member. This provides evidence to the theory that an anti-climate attitude tends to be a pillar of the Republican identity across the nation. Although there is a 0.4 correlation between being a Republican and the proportion of campaign funding that is provided by the energy and natural resources sector, there did not appear to be evidence of multicollinearity in the model, signaling that each variable plays an important and independent role in likelihood of voting yes. For all Congress members receiving more than 5% of campaign funding from this sector, over 87% of Democrats (7/8) voted no, and 100% of Republicans (21) voted no. Therefore, even though it is more likely for Republicans to receive donations from this sector, when Democrats also have this support, it appears to impact their vote. It is unclear whether these Congress members voted a certain way because they received this funding or received funding because they voted a certain way. Past research has found evidence to support the "investment hypothesis", where oil and gas companies financially reward members of Congress for voting a certain way, rather than providing money to these legislators so that they vote a certain way (Goldberg et al., 2020).

The model shows that the probability of voting yes on a bill increased over the years. However, this is a tricky variable to interpret because each year represented a different climate bill, and the third year represented a different chamber of Congress. Therefore, it is possible that it is not the time aspect that corresponded to a probability higher, but rather the bill's content or the chamber of Congress (House versus Senate). To address this in the future, there are a couple of things that could be done. First, there is a need to have a much larger sample of bills and voting records across the years from both chambers of Congress. However, this is restricted by the actual number of energy- and climate-related bills that have existed throughout history and have seen votes on the floor. Second, in this model I had the assumption that the three bills were of similar scale. If another model were to increase the range and number of bills included, I anticipate the need to create a numerical scale to measure the potential impact and costs associated with each policy in order to control for more qualitative aspects.

Lastly, it is interesting that longer tenure in this model corresponds to a higher likelihood of voting yes and that males are more likely to vote yes, despite the underlying data showing a smaller proportion of males vote yes than females. The three bills modeled here were all from over a decade ago, when Congress largely consisted of white males. It will be interesting to see as Congress becomes more diverse and brings in fresh perspectives how these relationships may change.

Conclusion

In conclusion, my hypothesis that right-leaning political party affiliation, more money spent on lobbying efforts against, and the longer ago it was proposed all significantly decrease the probability that an energy or climate-related measure or bill is passed was supported in RS2 but not RS1.

The research of the state level ballot data presented challenges in appropriately capturing qualitative aspects of the measures in the model. Therefore, the model was not successful in capturing statistically significant evidence to support what types and scale of measures are more likely to pass. However, the model did highlight the importance of campaign finance and the role of Hispanic representation in the outcome. To further this research, future studies could look at using surveying methods to sample the voting population of specific ballot measures to explicitly ask voters why they voted a certain way on a particular measure. This survey could include questions about the voter's previous perception and knowledge on energy and climate issues, perceived costs, perceived impact, positive or negative reaction to the language, and exposure to ads in support or against the proposed measure. This would allow the researcher to measure various perceptions against the actual outcomes and ballot attributes. Future research could also develop a more standardized methodology for measuring voters' perception of the impact (both cost and scale) of ballot measures to create apples-to-apples comparisons across measures and better identify if there is a relationship between that perception and political feasibility exists.

RS2 modeling largely supported the hypothesis that Republicans are less likely to vote yes on climate legislation and the more money that is received from the energy and natural resources sector, the higher the likelihood of a vote no. Legislation in later years was also more likely to get a yes vote, but there may be confounding variables at play here as identified above. Future studies could measure whether past voting records affect future voting records and what happens when a seat changes parties. Researching these questions may help us better understand the relationship between tenure and voting record. Another study could also look more in depth at the campaign finance data corresponding to a larger range of voting records related to energy and climate – the use of feature selection for which companies or dollar values influence votes more and use of a random forest model classifier could provide meaningful insight into the relationship between money in politics and voting outcomes. This kind of influence has been exposed through qualitative evidence as displayed in the novel Kochland (Leonard 2019), but data analysis may expose a larger machine of monetary influence in the system preventing political feasibility that runs contrary to public opinions.

The results from this research largely supports past findings. More research, as suggested above, needs to be conducted at the state level to determine the factors that most impact political feasibility at the ballot box. At the Federal level, in order to maximize the probability that a piece of climate legislation gets passed, action should be taken to expose and remove the influence of campaign finance, or the ability of campaign finance to influence results, by setting caps on single donors or donations from a single industry, as well as by reaching across the aisle and finding common ground with Republican allies that will support some form of climate and energy policies.

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Biographical Statement

Hallie Cramer is in her final year as a Master's student in the Johns Hopkins University Energy Policy and Climate Program. She received a bachelor's degree in economics and statistics from Duke University. In the professional world, she has experience from energy consulting and technology companies as an analyst, data scientist, and technical program manager. Her current role at Google as a carbon-free energy analyst and program manager focuses on managing the data, tools, and programs to help target 24/7 clean energy across Google's data center operations. Some of her academic interests include the psychology of climate inaction, using policy and markets to create demand for a sustainable economy, and emerging energy technologies.